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Commission canadienne de sûreté nucléaire

REGULATORY GUIDE

G-219

DECOMMISSIONING PLANNING FOR LICENSED ACTIVITIES

Published by the
Canadian Nuclear Safety Commission
June 2000

Canada

REGULATORY DOCUMENTS

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DECOMMISSIONING PLANNING FOR LICENSED ACTIVITIES

1.0 PURPOSE

This regulatory guide provides guidance regarding the preparation of decommissioning plans for activities licensed by the Canadian Nuclear Safety Commission (CNSC) in Canada. It provides also the basis for calculating the financial guarantees discussed in the Regulatory Guide G-206, *Financial Guarantees for the Decommissioning of Licensed Activities*.

2.0 SCOPE

This guide presents information of interest to those who have incurred, or expect to incur, obligations with respect to the decommissioning of activities licensed by the CNSC. Licences issued by the CNSC may contain conditions with respect to the requirements for the submission of decommissioning plans and their associated financial guarantees.

3.0 INTRODUCTION

The CNSC requires that planning for decommissioning take place throughout a licensed activity's life-cycle, and that both a preliminary decommissioning plan and a detailed decommissioning plan be prepared for approval by the CNSC.

A preliminary decommissioning plan should be filed with the CNSC as early as possible in the life-cycle of the licensed activity. Specific references to and requirements for decommissioning can be found in the Nuclear Safety and Control Act and the CNSC regulations for uranium mines and mills, class I nuclear facilities and class II nuclear facilities. In the case of licensees who are licensed for the possession and use of sealed sources only and where there is no potential for contamination of facilities associated with the licensed activity(s), a statement acceptable to the CNSC detailing the disposition of such sources will be considered sufficient to fulfill the requirements for the submission of a preliminary decommissioning plan. The plan should be revisited and updated as necessary.

This guide describes those decommissioning planning requirements and the regulatory and policy basis for them. Generic outlines of the structure and content of both preliminary and detailed decommissioning plans are presented emphasizing the factors that will assist in determining an appropriate work plan structure, level of detail, and flexibility in a specific plan. Key elements of the generic preliminary and detailed plan are elaborated upon. Those elements include: materials and waste management planning (including clearance level identification); radiological surveys; conventional health,

safety and security; emergency response; quality assurance; financial guarantees; environmental assessment; and final end-state reporting. Example outlines of decommissioning plan work packages for different types of nuclear facilities are provided in the Appendix.

4.0 DEFINITION OF TERMS

Certain terms found in this guide are defined below in alphabetical order:

ALARA
The principle of keeping radiation doses As Low As Reasonably Achievable, social and economic factors taken into account[1].

clearance levels
The maximum permissible concentrations of radioactivity in or on materials, equipment and sites to be released from regulatory control (e.g., Bq/g, Bq/cm^2, near-contact dose rates). Clearance levels may be expressed as "unconditional" or "controlled" depending on whether the specific pathways of release, or destinations for reuse, recycling and/or disposal are specified.

contamination (radiological or non-radiological)
A manufactured substance (or natural substance concentrated by human activity to a level not normally found in nature) that is in air, on/in solid materials, soil, surface water, or ground water at a concentration or quantity that could pose a risk to human health or the environment.

decommissioning
Those actions taken, in the interest of health, safety, security and protection of the environment, to retire a licensed activity/facility permanently from service and render it to a predetermined end-state condition.

de minimis dose
A level of exposure to ionizing radiation which is considered to pose a negligible or trivial risk to humans and where the expenditure of additional resources to further mitigate that risk is not justifiable[2].

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1. For additional guidance on maintaining ALARA for licensed activities refer to AECB Regulatory Guide G-129, *The Requirement to Keep All Exposures as Low as Reasonably Achievable*.
2. For further information on the de minimis concept, refer to AECB Regulatory Document R-85, *Radiation Protection Requisites for the Exemption of Certain Radioactive Materials from Further Licensing Upon Transferral for Disposal* (August 1989).

detailed decommissioning plan
A plan setting out the detailed work program, safety and environmental protection procedures, and management systems that will be followed in the decommissioning of a licensed activity/facility. Detailed decommissioning plans should evolve from the preliminary decommissioning plan.

end-state (final or interim)
The proposed physical, chemical and radiological condition of the facility at the end of the decommissioning program. Where a decommissioning program is to take place in discrete phases, the interim end-state objectives for each phase should be defined.

financial guarantee
The establishment and maintenance of a financial arrangement that will assure adequate funding of the decommissioning program.

institutional control
The control of residual risks at a site after it has been decommissioned and released from CNSC licensing control via a licence to abandon. These controls, overseen or maintained by another institution, are either "active" (e.g., involving mechanical systems and continuous or intermittent human intervention to monitor and control the risk), or "passive" (e.g., the registration or posting of information that will provide a warning against the remaining hazards). The use of institutional controls over the long-term should be justified[3].

life-cycle planning
A planning process for decommissioning that begins in the design and construction phases of a facility, remains responsive to new information obtained during operations, culminates in a detailed plan for CNSC approval at the end of operations, and remains flexible and adaptive to conditions encountered during the actual decommissioning process.

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3. Refer to AECB Regulatory Document R-104, *Regulatory Objectives, Requirements and Guidelines for the Disposal of Radioactive Wastes - Long-term Aspects* (June 1987).

planning envelope (see also "work package")
A definable part or area of a facility that is sufficiently removed from, or otherwise independent of, other parts or areas so that the strategic approach to decommissioning that part or area may be planned in a relatively independent manner. For example, processing, administration, and waste management areas may all fall within relatively independent decommissioning planning envelopes. Planning envelopes should be identified in the preliminary decommissioning plan and may be used as a basis for pursuing a program of multiple detailed decommissioning plan approvals. They may also be used as preliminary boundaries for controlling the spread of contamination during decommissioning, or for prioritizing the main sequence of activities.

preliminary decommissioning plan
An overview of the proposed decommissioning approach that is sufficiently detailed to assure that the proposed approach is, in the light of existing knowledge, technically and financially feasible and appropriate in the interests of health, safety, security and protection of the environment. The preliminary decommissioning plan defines areas to be decommissioned and the general structure and sequence of the principle decommissioning work packages envisioned. As such, the preliminary plan forms the strategic basis for establishing financial guarantees, and provides the structural outline of the subsequent detailed decommissioning plan(s).

storage-with-surveillance
A planned stage during a decommissioning program where the remaining contaminated materials, equipment and site(s) will be placed under controlled surveillance for a specified period of time. Licensing control by the CNSC remains in effect during such periods.

work package
A logical grouping of relatively contiguous decommissioning tasks aimed at achieving a particular step in the overall decommissioning project. For example, the removal of a specific facility component (including, as necessary, its decontamination, disassembly and delivery to a waste segregation area) could constitute a single work package. Work packages should form the basis of the decommissioning cost estimates and the preliminary conceptual and detailed project schedules. The number and scope of individual work packages will depend on the physical complexity of a facility, the nature of the hazards present, and whether the planning is at the preliminary or detailed stage.

5.0 DECOMMISSIONING PLANNING

5.1 Life-cycle decommissioning plans

The CNSC requires that decommissioning planning be completed in two phases.

The preliminary decommissioning plan is filed with the CNSC as early as possible in the life-cycle of the activity or facility. The plan should be revisited and updated as necessary. In the case of nuclear facilities, specific requirements for decommissioning planning are set out in the CNSC regulations for uranium mines and mills, and class I and II nuclear facilities.

The preliminary plan documents, as appropriate, the preferred decommissioning strategy and end-state objectives; the major decontamination, disassembly and remediation steps; the approximate quantities and types of waste generated; an overview of the principal hazards and protection strategies; an estimate of cost; and the method(s) of guaranteeing financing for the decommissioning activities.

The detailed decommissioning plan is filed with the CNSC for appropriate licensing action prior to beginning decommissioning activities. This plan normally refines and adds procedural and organizational details to the preliminary plan.

Once approved by the CNSC, the detailed plan will be incorporated into a licence authorizing the decommissioning.

5.2 Regulatory requirements and CNSC policies for decommissioning planning

5.2.1 CNSC regulations, policies and related guides

The CNSC's requirements for preliminary and detailed decommissioning planning are rooted in the Nuclear Safety and Control Act and its regulations.

In support of current statutory requirements and policies are some other CNSC policies and guides. The most directly relevant are:

G-206 *Financial Guarantee Guide for the Decommissioning of Licensed Activities*;

R-104 *Regulatory Objectives, Requirements and Guidelines for the Disposal of Radioactive Wastes – Long-term Aspects* (June 1987); and

R-85 *Radiation Protection Requisites for the Exemption of Certain Radioactive Materials from Further Licensing Upon Transferral for Disposal* (August 1989).

There may be other CNSC policies and guides relevant to a decommissioning project. Applicants and licensees should consult their assigned CNSC project/ licensing officer for assistance in this regard.

5.2.2 Other federal and provincial laws and regulations

Applicants and licensees may have legal obligations for their decommissioning plans and projects under other federal and provincial laws.

CNSC staff may offer to coordinate the distribution and exchange of pertinent information among the applicable regulatory bodies; however, this does not absolve an applicant from its direct legal responsibilities under the applicable statutes and regulations.

Under the Canadian Environmental Assessment Act, the CNSC is responsible for ensuring that environmental assessments of proposed decommissioning projects (that are subject to and not specifically excluded from this Act) are completed and taken into account prior to authorization. At the beginning of the detailed planning phase, licensees should consult with their CNSC project/ licensing officer to determine if this Act will apply to the decommissioning project and, if so, what type and scope of environmental assessment is required.

6.0 STRUCTURE AND CONTENT OF DECOMMISSIONING PLANS

The following subsections describe the roles of the preliminary and detailed plans, and provide generic outlines of the required structure, content and level of detail of each plan type. Because the outlines are generic and applicable to all types of activities and facilities, licensees and applicants of small, low-hazard facilities may question how such outlines are applicable. Section 6.3, which deals with factors affecting level of detail and plan flexibility, and the example outlines in the Appendix, provide important contextual information in this regard.

6.1 Preliminary decommissioning plans

6.1.1 Role and timing of the preliminary plan

A preliminary decommissioning plan should be filed as early as possible in the life-cycle of a licensed activity. If a preliminary plan has not been filed for an existing activity or operating facility, one should be prepared as soon as possible.

The main roles of the preliminary decommissioning planning process and plan are to:

1) provide an opportunity to proactively conduct activities and design, construct and operate facilities in a manner that will facilitate the decommissioning process (refer to section 7.0 for further guidance on this subject);
2) document a preferred decommissioning strategy which, in light of current knowledge, represents a technically feasible, safe and environmentally acceptable approach; and
3) provide a structured and dynamic outline for establishing and maintaining an acceptable financial guarantee program, and preparing a detailed decommissioning plan.

6.1.2 Content of the preliminary decommissioning plan

A preliminary decommissioning plan should include:

1) a brief description of, and diagram showing, the various areas, components and structures to be decommissioned — grouped, where appropriate, into logical decommissioning planning envelopes, including an indication of whether more than one detailed decommissioning plan will be prepared (i.e., for relatively independent areas and/or phases of the overall decommissioning program. See section 6.1.3 for defining multiple projects);
2) an overview of the principal radiological, chemical and physical conditions predicted to exist at the end of operations in each of the above areas, components and structures, highlighting any areas of significant uncertainty;
3) a discussion of the general types of hazards, associated with the above conditions, that could be encountered during decommissioning;
4) identification of any features of the surrounding natural and social environment that could be significantly affected by the decommissioning process;
5) a statement of, and rationale for, the preferred strategic approach to decommissioning within each planning envelope (i.e., prompt removal, deferred removal, *in-situ* confinement/disposal, or some combination of these general strategies. Refer to section 8.0 for additional guidance on identifying a basic strategic approach);
6) a statement of the final end-state objectives in each planning envelope, including any predicted requirement for long-term institutional controls;

7) a description of the main decommissioning work packages envisioned in each planning envelope; including for each work package:
   - the general technical approach;
   - any principal hazards anticipated;
   - the general strategy(ies) for ensuring the protection of decommissioning workers, the public and the environment; and
   - the approximate type, quantity and disposition of wastes arising;

   (The number and scope of individual work packages should be a function of where the principle hazards are expected to exist in the decommissioning process; higher hazard areas should be represented by a finer work-package breakdown. Refer to section 6.3 for further guidance on level of detail, building plan flexibility, and managing uncertainty.)
8) a conceptual schedule showing the approximate duration and sequencing of work packages, and any proposed extended periods of storage-with-surveillance;
9) reasonably conservative cost estimates (based on the work-packages) for labour, materials, equipment, waste management, environmental assessment, monitoring, and administration (e.g., training, safety, licensing, project management, government and public liaison);
10) the proposed financial guarantee arrangements;
11) a description of the facility operational records that will be maintained for the purpose of both periodically updating the preliminary plan, and preparing the detailed decommissioning plan(s).

Preliminary plans should be periodically updated in light of evolving technologies, regulations, operational information, and cost estimates.

6.1.3 Defining multiple projects in a single preliminary plan

It may be appropriate to divide a complex facility into a number of relatively independent decommissioning projects. For example, a large facility may be divided into areas (i.e., planning envelopes) that, from the point of view of decommissioning, are relatively physically independent from one another. It may also be possible to divide a decommissioning program into relatively independent phases on the basis of requirements for lengthy periods of storage-with-surveillance, or to include components of the licenced activity/facility that could be decommissioned during its operating life.

If such partitioning is judged to be acceptable by the CNSC, separate detailed decommissioning plans may be prepared for approval prior to the commencement of each project.

6.2 Detailed decommissioning plans

6.2.1 Role and timing of the detailed plan

Once approved by the CNSC, the detailed plan will be incorporated into a licence authorizing the decommissioning. Section 6.3 provides specific guidance on how to build an appropriate level of flexibility into a detailed plan to minimize regulatory delays during its implementation.

6.2.2 Content of the detailed plan

The detailed plan is normally a refinement and procedural "fleshing-out" of the work package structure established in the preliminary decommissioning plan.

The results of detailed post-operational contamination surveys, assessments of hazard and environmental impacts and new technological developments or regulatory requirements may precipitate a change in the decommissioning strategy (see section 8.0 on choosing a basic decommissioning strategy).

A detailed decommissioning plan should include the following elements:

1) a brief description of, and diagram showing, the various areas, components and structures to be decommissioned — grouped where appropriate into logical decommissioning planning envelopes;
2) a history of the operation and any incidents or accidents that may affect the decommissioning;
3) a statement of the final radiological, physical, and chemical end-state objectives for the site; (where more than one detailed decommissioning plan is required in a phased program, interim end-state objectives and monitoring programs for deferral periods must be provided in each detailed plan)
4) a description of any specific requirements for long-term institutional controls;
5) results of a comprehensive and systematic survey of the radiological and other potentially hazardous conditions at the facility (see section 10.0), including the identification and description of any remaining significant gaps or uncertainties in the measurement or prediction of these conditions;
6) overview of the decommissioning strategy for each planning envelope, highlighting any significant changes from the preliminary plan strategy (refer to section 8.0 on selecting a basic strategy);

7) a description of each decommissioning work package, including an overview of:
   - the step-wise technical approach;
   - the nature and source of any potentially significant risks to the workers, public and environment, including estimates of doses;
   - the specific standard or project-specific procedures or technologies proposed to mitigate those risks; and
   - the quantities, characteristics and disposition of wastes arising (refer to section 6.3 for guidance on level of detail, building flexibility and managing uncertainties).
8) a schedule showing the proposed start-date; the approximate duration and sequence of work packages (and periods of storage-with-surveillance, if applicable); and the anticipated completion date;
9) a description of the waste management plan, including:
   - a description of the area, procedures, criteria and instruments that will be used to monitor and segregate wastes into different categories (radiological, non-radiological, hazardous and non-hazardous);
   - estimates of the quantities of waste expected to arise in each category over time (based on the work package descriptions in item 6 above);
   - specific plans for the reuse, recycling, storage, or disposal of that waste; and
   - clearance levels for the release of materials and equipment;
10) an assessment of the potential environmental effects of the proposed decommissioning program and the measures that will be employed to mitigate and monitor those effects;
11) a conservative cost estimate (based on the work-packages) for labour, materials, equipment, waste management, environmental assessment, monitoring, and administration (e.g., training, safety, licensing, project management, government and public liaison);
12) the financial guarantee arrangements;
13) a description of any public consultations undertaken in the preparation of the plan, including a summary of any issues raised and how they were resolved;
14) a description of the organizational project management structure;
15) a quality assurance program;
16) an emergency response plan;
17) a site security program;
18) a radiation protection program;
19) an environmental protection and monitoring program;
20) a personnel training program;

21) a human factors program, including application of appropriate considerations to human factors analyses, training provisions, use of contractors, procedure development and ergonomic issues;
22) a summary of conventional occupational health and safety issues, and the training and protection programs to address them;
23) a listing of federal and provincial regulatory agencies involved in the decommissioning project;
24) a final radiation survey program with interpretation criteria;
25) a listing of the facility/activity operating and decommissioning records that will require retention for the long term; and
26) a table of contents for the final report.

6.3 Factors affecting level of detail and plan flexibility

6.3.1 Facility characteristics

The generic decommissioning planning process can be applied to all types of licensed activities. For example, the decommissioning plan for a small facility with few residual hazards (such as a particle accelerator) may consist of a brief summary of a single-phase, relatively low-cost project that will draw on operating budgets, and employ standard disassembly, decontamination and radiation protection procedures in the completion of one or two work packages. For the larger, more radiologically complex facilities (such as a nuclear power plant or uranium mine), the same planning process may generate plans that describe a multi-phased program addressing a variety of different facility components and/or sites, employ a number of specialized decommissioning and radiation protection procedures and require extensive separately-secured funding.

Similarly, knowledge of facility characteristics will also guide where flexibility can be built into the decommissioning plans. For example, where a work package can be safely executed in a number of different ways, the freedom to choose from those options can be built into the work package description. Where a range of possible hazardous conditions have been predicted for a particular area, a corresponding range of acceptable strategies for the associated work package can be outlined for decision later. A worst-case approach to planning a work package may be another way to build flexibility into the plan.

Generic examples of decommissioning plan work packages for different types of nuclear facilities are provided in the Appendix.

6.3.2 Uncertainty

Significant uncertainties may exist at the preliminary decommissioning planning stage, particularly where decommissioning is not scheduled to take place for several decades, where highly complex operations may be involved, and where the evolution of regulatory requirements, technologies and waste management services is unknown.

The preliminary plan should be based on the best available conservative information and predictions, and consider any special issues should an earlier unscheduled facility closure occur. Broadly scoped and generally described work packages in the preliminary decommissioning plan may require further subdivision and refinement over time, and at the detailed plan stage when the uncertainty is less.

Where a major uncertainty remains in the detailed plan (e.g., because of the inability to access for survey, or otherwise predict the hazardous characteristics of an area or component), it may be acceptable to build CNSC approval of a specific work package directly into the plan schedule.

7.0 THE LIFE-CYCLE APPROACH TO DECOMMISSIONING PLANNING

Life-cycle decommissioning planning assists in ensuring that:

1) a facility/activity is designed and operated in a manner that will facilitate decommissioning;
2) licensees are able to prepare for the costs of decommissioning;
3) potentially difficult or challenging technical problems are identified well in advance so that the solutions can be pursued in a proactive manner; and
4) portions of the facility/activity can be decommissioned thus reducing liabilities and permitting assessment of the decommissioning while the licensee continues operations.

The following sections provide guidance on how to effectively benefit from life-cycle decommissioning planning.

7.1 The design, construction and commissioning stages

There are many advantages to designing and constructing a facility with the requirements for future decommissioning explicitly in mind.

For example, a uranium mining facility could minimize the need for long-term institutional controls and optimize long-term risk by depositing mill tailings into a mined-out pit.

Similarly, reactor facilities can be designed and constructed in modules easing the dismantling process and reducing worker dose. Proper selection of materials and surface treatments in areas likely to become contaminated can simplify the decontamination process and help maximize the recovery of valuable materials. Finally, the design of surface shapes, accessibility and configurations can reduce the complexity and cost of decommissioning, possibly avoiding the need to develop specialized technologies and equipment.

7.2 Maintaining a preliminary decommissioning plan during facility operations

The initial preliminary decommissioning plan will be based largely on predictions of the type and quantity of contamination that are expected to accumulate in different parts of a facility under normal operating conditions. During the operations phase, these predictions should be monitored and, if necessary, revised with actual survey data. Periodic inspections and sampling of known or potentially contaminated areas should be conducted. Similarly, all unplanned events and accidents that could lead to contamination should be thoroughly investigated and sample analyses carefully documented (refer to section 10.0 on radiological surveys).

The preliminary decommissioning plan should be reviewed and updated in light of operational experience and technological advances. All significant changes should be discussed with the assigned CNSC project/licensing officer.

During the facility operation stage, the CNSC may inspect the facility operational records and preliminary decommissioning plan for the purpose of ensuring that the plan and the financial guarantee program remain consistent with the projected scale of the decommissioning effort.

8.0 CHOOSING A BASIC STRATEGY FOR DECOMMISSIONING

Once the physical decommissioning planning envelopes have been defined in the preliminary planning stage, and before the individual work packages are identified, it may be useful to map out the basic strategic approach to decommissioning within each envelope. This is more important for large, complex facilities that may need to be decommissioned in several phases over a long period of time, or where on-site disposal of large quantities of waste may be necessary (e.g., uranium mine tailings). Choosing the basic strategy may also be important where intense, but relatively short-lived (half-life less than 10 years) radioactivity may be present (e.g., that related to cobalt 60 activation in reactor core components), or where anticipated waste management capacity problems will need to be resolve.

The following basic alternative strategies should be evaluated for each planning envelope:

- **prompt removal**;
- **deferred removal** (to allow for the decay of relatively short-lived nuclides (e.g., half-lives of less than 10 years), or to await the availability of waste disposal capacity);
- ***in-situ* confinement** (to secure and abandon the affected portions of the facility in place); and
- **combinations of the above**.

Where a clear strategic preference is not immediately apparent, the alternative strategies should be compared using a simple detriment-benefit evaluation method. The evaluation method should ensure that the relative advantages and disadvantages of the remaining strategies can be objectively compared in a systematic and traceable fashion.

Examples of factors that may be relevant to the evaluation of alternative decommissioning strategies include:

- forms and characteristics of radioactive and conventional contaminants;
- integrity of containment and other structures over time;
- availability of decontamination and disassembly technologies;
- potential for recycle or reuse of equipment and materials;
- availability of knowledgeable staff;
- potential environmental impacts;
- potential worker and public doses;
- end-state objectives and site redevelopment pressures;
- potential revenues, costs and available funding;
- availability of waste management and disposal capacity;
- regulatory requirements; and
- public input.

In some cases, after a preferred general strategy has been identified for a planning envelope, it may be necessary to conduct secondary strategic evaluations of the alternative methods of implementing that strategy. For example, it may be determined that in-situ confinement with long-term institutional control is the preferred strategy for a mine tailings site; however, alternative methods, such as water or soil covers or relocation will normally need to be evaluated before the specific work packages can be identified.

9.0 MATERIALS AND WASTE MANAGEMENT

9.1 Materials and waste management plan

The detailed decommissioning plan must include a materials and waste management plan that describes the systematic process for how materials will be moved from the disassembly areas to areas designated for monitoring, segregating, processing, packaging, transfer or disposal. Those monitoring and processing areas should be designed and operated to keep recyclable and reusable materials separate from waste materials.

The ultimate destination of materials arising from decommissioning activities, and the ability of those destinations to accommodate the types and volumes of material, should be assessed and documented in the preliminary decommissioning plan and verified in the detailed decommissioning plan.

9.2 Radiological clearance levels

Decommissioning programs should optimize the clearance of materials and sites from CNSC regulatory control. Materials that cannot be cleared must either be transferred to another licensed facility or permanently disposed on the site.

Clearance levels should be proposed for surface and/or bulk contamination (i.e., alpha, beta, gamma activity in Bq/cm^2, or Bq/g). For site clearance, it may also be appropriate to propose activities in soils, gamma fields above background and, if applicable, concentrations of radon in indoor air.

Different clearance levels may be proposed based on the specific radionuclides involved and the type of clearance sought (i.e., unconditional or controlled). In all cases, the resulting dose must be below the regulatory limits and in compliance with ALARA principle.

Decommissioning applicants may elect to apply generic clearance levels acceptable to the CNSC or propose site-specific levels. Site-specific clearance levels must be supported with the details of how the estimates of dose to critical groups were calculated. CNSC staff should be consulted early in such development of clearance levels and selection of calculation methods.

9.3 Non-radiological hazardous waste management

Decommissioning may generate significant quantities of non-radiological hazardous substances. These may be regulated by other federal and provincial agencies.

Decommissioning applicants should assess the potential for generating those substances and incorporate the necessary precautions and reporting and management procedures into their decommissioning plans. In this way, a joint regulatory review of a single document could be facilitated (refer to section 5.2.2 on other applicable federal and provincial laws and regulations).

10.0 RADIOLOGICAL SURVEYS

Assessments of radiological conditions prior to and during decommissioning are an integral part of decommissioning planning. Preliminary plans should describe background conditions, project conditions during operations and how data collected during operational radiation surveys will be used in constructing the radiological knowledge-base necessary for preparing and implementing the detailed decommissioning plan.

10.1 General radiation survey requirements for decommissioning

Radiation surveys are performed at various stages in the decommissioning planning process:

- **pre-operational**
  to establish background conditions prior to construction;
- **operational**
  to add to the radiological contamination knowledge-base;
- **post-operational**
  to complete and refine the knowledge-base for detailed planning;
- **during decommissioning**
  to support worker radiation protection programs, environmental monitoring programs, and releases of materials and equipment from the site;
- **post-decommissioning**
  to support site de-licensing and required follow-up.

The decommissioning plans should identify, for all stages, types of measurements to be made, instruments to be used and their calibration, and proposed laboratory procedures.

10.2 Site clearance survey requirements

For the final site clearance survey, the remaining facility components or sites should be divided into discrete survey areas (i.e., locations where similar activities occurred and contamination characteristics are known to be reasonably consistent and uniform).

Large surfaces in each survey area should then be mapped using an appropriately sized survey grid. Site-specific conditions and judgement should be applied in delineating the survey areas and grids to ensure that statistically representative monitoring and sampling will be achieved. All data points should be linked to specific locations on the survey grid.

Specific procedures for monitoring any irregular objects in the survey areas (such as door knobs, light fixtures, shelving, and waste rock piles) should also be specified in decommissioning plans.

CNSC staff will normally conduct an independent audit survey of the site prior to acceptance of the final end-state report (see section 15.0).

11.0 HUMAN FACTORS

Decommissioning planning throughout the life cycle of the licensed activities should consider human factors to ensure safe, efficient and effective decommissioning.

The CNSC should be contacted concerning its current expectations with respect to human factor aspects.

12.0 CONVENTIONAL HEALTH SAFETY AND SECURITY

Decommissioning activities may involve a variety of conventional (non-radiological) hazards.

Detailed decommissioning plans should describe the nature of the conventional hazards that may be encountered during each work package and how all applicable provincial and federal laws and regulations governing conventional health safety will be addressed (see section 5.2.2).

Some decommissioning sites may be attractive to intruders. The detailed decommissioning plan should indicate how site security will be maintained with respect to the safety of unauthorized persons entering the site or taking contaminated materials from the site.

13.0 EMERGENCY RESPONSE

Decommissioning activities can increase the risk of emergencies such as fire, explosion, sudden unplanned releases of contaminants to the environment, or serious personal injury. Each work package should be examined for the potential and consequences of such emergencies.

A separate section of the detailed decommissioning plan should summarize what measures will be taken to prevent, mitigate and respond to such emergencies.

14.0 QUALITY ASSURANCE

Quality assurance (QA) includes the organization of responsibilities and accountability; qualification and training of personnel; written plans, procedures and manuals; routine equipment performance and maintenance checks; formal audit and inspection processes; structured program review and feedback mechanisms; security and safety; record keeping; and data management systems.

A separate section of the detailed decommissioning plan should identify all aspects of QA for the decommissioning project.

The CNSC should be contacted concerning its current expectations with respect to quality assurance aspects.

15.0 FINAL END-STATE REPORTING

At the completion of a decommissioning project, an end-state report should be submitted to the CNSC. Where the decommissioning program involves the completion of a number of separately approved decommissioning projects, interim end-state reports should be submitted.

This report should review the completed decommissioning process, noting any significant deviations from the detailed decommissioning plan. It should clearly document (using actual survey results) that the planned end-state conditions have been met and, if not, why not. The report should describe any proposed further licence requirements, or long-term institutional controls for the site.

These reports are one of the tools which CNSC staff will use to verify compliance with the licence authorizing the decommissioning and serve as an input into any further licensing actions.

APPENDIX
EXAMPLE DECOMMISSIONING WORK PACKAGES

URANIUM MINE AND MILL

URANIUM REFINING AND CONVERSION

POOL-TYPE RESEARCH REACTOR

NUCLEAR POWER PLANT

URANIUM MINE AND MILL

Recycle and/or reuse of materials and equipment should be maximized to the extent practicable.

PLANNING ENVELOPES	WORK PACKAGES
Mine workings	1) Remove salvageable equipment and hazardous materials 2) Stabilize/fill underground workings/open pits 3) Assess crown pillar stability 4) Seal shafts, raises, declines and portals 5) Remove headframe and hoists 6) Remove ancillary structures and services/remediate contaminated soils 7) Grade and revegetate immediate area
Mill site	1) Remove coarse ore in storage 2) Remove process chemicals and hazardous materials in storage 3) Remove contaminated equipment and vessels for disposal 4) Remove salvageable equipment and materials, decontaminate as needed 5) Demolish remaining structures and tanks 6) Remediate contaminated soils 7) Grade and revegetate immediate area
Tailings management area	1) Construct/upgrade containment structures for long term 2) Construct/improve water drainage or diversion works 3) Recontour tailings 4) Place final cover (soil, rock, water, etc.) 5) Install/upgrade monitoring/treatment facilities 6) Remove pipelines, pumps and other ancillary structures 7) Grade and revegetate immediate area
Waste rock management area	1) Stabilize with respect to infiltration/acid generation 2) Recontour/grade and vegetate or relocate for disposal as required
Hazardous material storage area	1) Remove materials inventory 2) Remove contaminated tanks and structures for disposal 3) Demolish remaining structures and tanks 4) Remediate contaminated soils 5) Grade and revegetate immediate area
Effluent treatment	1) Remove remaining effluents and chemicals in storage 2) Remove unnecessary treatment plant, piping and other structures 3) Remediate mine water, sewage and other effluent treatment ponds and sludges 4) Grade and revegetate immediate area

PLANNING ENVELOPES	WORK PACKAGES
Ancillary buildings and services	1) Dismantle boiler and powerhouse 2) Remove power lines and substations 3) Remove potable water supply system 4) Remove sewage treatment system 5) Remove non-hazardous material and equipment warehousing 6) Remove camp accommodations 7) Remove mechanical shops 8) Remove administration and security structures 9) Regrade access roads, private airstrips and remove culverts 10) Grade and revegetate immediate area

Note: A basic strategy for decommissioning in each planning envelope should be developed as discussed in section 8.0 of this guide. A description of each work package should be included in the preliminary and detailed decommissioning plans as discussed in sections 6.1.2 and 6.2.2 of this guide.

URANIUM REFINING AND CONVERSION

Recycle and/or reuse of materials and equipment should be maximized to the extent practicable.

PLANNING ENVELOPES	WORK PACKAGES
Materials shipping, receiving and storage areas	1) Remove product / yellow-cake inventories 2) Decontaminate and remove equipment, tools, conveyors, hoists, etc.
Digester process area	1) Remove contents and loose contamination from primary and secondary digesters 2) Dismantle digester vessels 3) Remove ancillary piping, valves and electrics 4) Remove other equipment and tools
Solvent extraction process area	1) Remove contents of vessels and piping 2) Decontaminate and dismantle feed tanks 3) Decontaminate and dismantle column trains 4) Decontaminate and dismantle settling tanks 5) Dismantle ancillary piping, valves, electrical and conveyance systems
Reactor areas	1) Remove contents of denitrification reactors 2) Decontaminate and dismantle reactor vessels 3) Decontaminate and remove reaction gas scrubber system 4) Remove active drains
Effluent management systems	1) Remove contents of effluent neutralization vessels 2) Remediate effluent monitoring and treatment lagoons 3) Remediate storm water management lagoon 4) Remove final effluent discharge line 5) Decontaminate sumps 6) Decontaminate and remove raffinate evaporators 7) Decontaminate and remove liquor evaporators
Emission control system	1) Remove baghouse filter system 2) Remove central vacuum system
Solid waste management areas	1) Decontaminate uranium scrap area 2) Decontaminate and remove refuse incinerator 3) Decontaminate drum cleaning and processing area 4) Remove inventory and decontaminate low-level storage area
Maintenance and trades shops	1) Remove tools and equipment 2) Remove other materials and stores 3) Remove work benches, furniture, etc. 4) Dismantle mechanical and electrical rooms
Administrative offices and labs	1) Remove equipment, furniture and fixtures 2) Decontaminate laboratories and remove equipment
Chemical tank farm	1) Remove inventory 2) Dismantle and dispose of tanks

PLANNING ENVELOPES	WORK PACKAGES
Building surfaces and structure	1) Decontaminate interior floors, walls and ceilings as required 2) Decontaminate exterior surfaces as required 3) Remove HVAC ductwork 4) Remove plumbing, electrical and other services 5) Demolish structures
Site	1) Remove waste piles and other potentially contaminated materials 2) Remove contaminated soil and asphalt 3) Grade and revegetate immediate area 4) Final release survey

Note: A basic strategy for decommissioning in each planning envelope should be developed as discussed in section 8.0 of this guide. A description of each work package should be included in the preliminary and detailed decommissioning plans as discussed in sections 6.1.2 and 6.2.2 of this guide.

POOL TYPE RESEARCH REACTOR

Recycle and/or reuse of materials and equipment should be maximized to the extent practicable.

PLANNING ENVELOPES	WORK PACKAGES
Reactor building/room	1) Remove control/absorber rods and drive assembly 2) Remove core components 3) Remove experimental sites/equipment 4) Remove primary heat exchangers and piping 5) Dismantle secondary cooling system 6) Drain pool water 7) Remove pool liner 8) Dismantle pool walls 9) Dismantle water purification system 10) Remove fuel and fuel storage equipment 11) Remove control room equipment 12) Remove ventilation system 13) Remove water, electrical, sewer and other services 14) Dismantle cranes and hoists 15) Dismantle structure
Hot cells and labs	1) Remove equipment and supplies 2) Remove active drains 3) Remove fume hoods and breathing-air ventilation 4) Dismantle hot cells 5) Remove water, electrical, sewer and other services 6) Dismantle structures
Ancillary buildings	1) Remove equipment, tools and supplies 2) Remove water, electrical, air and sewer services 3) Dismantle structures
Site	1) Grade and revegetate immediate area 2) Final survey

Note: A basic strategy for decommissioning in each planning envelope should be developed as discussed in section 8.0 of this guide. A description of each work package should be included in the preliminary and detailed decommissioning plans as discussed in sections 6.1.2 and 6.2.2 of this guide.

NUCLEAR POWER PLANT

Recycle and/or reuse of materials and equipment should be maximized to the extent practicable.

PLANNING ENVELOPES	WORK PACKAGES
Calandria vault	1) Dismantle calandria internals and shells 2) Decontaminate vault 3) Segment and remove calandria vault
Reactor building	1) Remove steam generators 2) Remove primary heat transport pumps and piping 3) Remove moderator dump tanks 4) Dismantle and remove emergency core cooling system 5) Remove fuelling machine and ducts 6) Dismantle and remove internal concrete structures and shielding 7) Remove steel walkways, ladders and stairs 8) Dismantle containment structures and floor slab
Vacuum building and ducts	1) Dismantle structures (decontaminate as necessary)
Reactor auxiliary bay	1) Remove inventory of irradiated fuel 2) Drain and decontaminate bays 3) Segment and remove bays 4) Remove control centre equipment 5) Remove standby generators 6) Demolish structure
Turbine hall	1) Remove turbine generators 2) Remove other electrical and ancillary equipment 3) Demolish structure
Turbine auxiliary bay	1) Remove condenser 2) Remove condenser water circulating and service pumps/ piping 3) Remove de-aerator 4) Remove feedwater heaters, piping and other equipment 5) Raise structure
Service buildings	1) Remove inventory of liquid and solid wastes 2) Decontaminate, dismantle and remove waste management equipment 3) Remove equipment from and decontaminate maintenance shops 4) Remove equipment from and decontaminate laboratories 5) Remove other equipment and materials from stores 6) Demolish structure
Heavy water treatment and storage facility	1) Remove inventory of heavy water 2) Remove other equipment and materials 3) Decontaminate and dismantle structures
Water treatment system	1) Remove pumphouse 2) Remove water treatment equipment 3) Dismantle structures

PLANNING ENVELOPES	WORK PACKAGES
Administration building	1) Remove contents 2) Dismantle structures
Site	1) Remove services, roads, etc. 2) Final radiological and contaminants survey 3) Grade and landscape

Note: A basic strategy for decommissioning in each planning envelope should be developed as discussed in section 8.0 of this guide. A description of each work package should be included in the preliminary and detailed decommissioning plans as discussed in sections 6.1.2 and 6.2.2 of this guide.